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Gulf Region

Canadian Science Advisory Secretariat
Science Advisory Report 2014/040

ASSESSMENT OF ATLANTIC HERRING IN THE SOUTHERN GULF OF ST. LAWRENCE (NAFO DIV. 4T) TO 2013

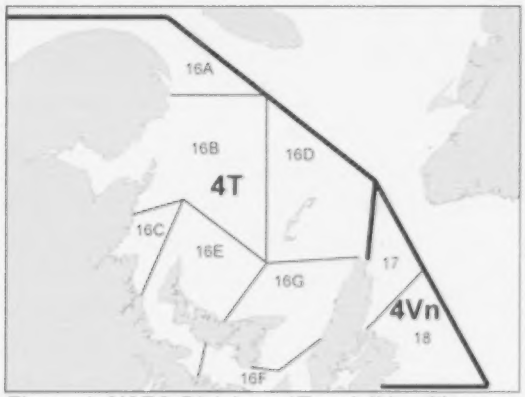

Figure 1. NAFO Divisions 4T and 4Vn with corresponding herring management zones.

Context

The stock area for southern Gulf of St. Lawrence herring extends from the north shore of the Gaspé Peninsula to the northern tip of Cape Breton Island, including the Magdalen Islands (Figure 1). Available information suggests that adults overwinter off the east coast of Cape Breton primarily in NAFO Division 4Vn. Southern Gulf of St. Lawrence herring are harvested by a gillnet fleet on spawning grounds and a purse seine fleet (vessels >65') in deeper water. The gillnet fleet harvests almost solely the spring spawner component in the spring, except for June, and almost solely the fall spawner component in the fall. The purse seine fleet harvests a mixture of spring and fall spawner components during their fishery. The percentages of spring and fall spawner components in the catch vary according to season and gear type. In recent years spring herring have been sold primarily for bait but historically were also used for the bloater (smoked herring) and filet markets. Fall landings are primarily driven by the roe, bloater and filet markets. TAC management was initiated in 1972. Currently there are approximately 2,610 gillnet licenses and 11 seiner licenses (>65'), 6 from 4T and 5 from 4R (west coast of Newfoundland). Assessments of the spring and fall spawning herring from the southern Gulf of St. Lawrence NAFO Division 4T are used to establish the TAC. In December 2005, a meeting on the assessment framework was held to determine spawning stock biomass reference points, to update the $F_{0.1}$ calculations and the methodology for short term projections. A meeting of the Regional Advisory Process was held March 11 and 12, 2014 in Moncton, N.B. to assess the status of the spring and fall spawner components of 4T herring in support of the management of the 2014 and 2015 fisheries. A review of the current length of 50% maturity was also provided as requested by DFO Fisheries and Aquaculture Management. Participants at the peer review included DFO scientists and fishery managers, representatives of the industry, and Aboriginal organizations.

August 2014

Canada

SUMMARY

Spring Spawner Component

- Reported landings of the spring spawner component in both the spring and the fall fisheries were 599 t in 2012 and 1,703 t in 2013. The spring spawner TAC was 2,000 t.
- The opinions of fixed gear harvesters from the telephone survey were that abundance of spring herring in 2012 and 2013 was similar to 2011.
- The mean gillnet catch rate in 2012 was the second lowest in the time series but the 2013 gillnet catch rate was higher than in 2012. The index has been declining since 1997 and remains at a low level in the series that starts in 1990.
- The 2012 and 2013 acoustic indices were slightly higher than in 2011 but the indices remain low in the series that starts in 1994.
- The stock is considered to be just above the limit reference point. Estimated abundance has increased in recent years from the low level estimated in 2006.
- Estimated exploitation rates in 2012 and 2013 are the lowest of the time series at 3% and 12%, respectively.
- The abundances of recent recruiting year-classes (at age 4) are below average.
- A catch option of about 2,000 t in 2014 would result in about an 80% probability of at least a 5% increase in biomass.
- Projections for the fisheries over the next two years show that the probability of an increase in biomass from January 2014 to January 2016 ranged from almost 100% with no catch to 93% with catches of 2,000 t each year.

Fall Spawner Component

- Reported landings of the fall spawner component in both the spring and the fall fisheries were 32,576 t in 2012 and 34,368 t in 2013. The fall spawner TAC was 43,500 t.
- The opinion of fixed gear harvesters from the telephone survey is that the abundance of fall herring has been decreasing since 2006.
- The mean gillnet catch rate has generally decreased since 2006 but the 2013 mean gillnet catch rate was higher than the two previous years.
- The acoustic index for ages 2 and 3 has been declining since 2006, except in 2012, and remains at a low level in the series that starts in 1994.
- Two assessment models that varied in the assumptions about catchabilities in the fixed gear for ages 4 and 5 were evaluated. There are reliability issues with the two models for assessing stock status and providing catch advice, therefore the results from both models are presented.
- The exploitation rate in 2013 was estimated to have been 31% under model 1 (no change in catchabilities of ages 4 and 5 since 2004) and 21% under model 2 (trend in catchabilities of ages 4 and 5 since 2004). The $F_{0.1}$ reference level for fall spawners is 25%.

- Estimated recruitment at age 4 shows generally similar patterns for both models: recruitment was below average in 2007 and 2012 and above average in 2008 and 2009. Recruitment was estimated to be above average in 2013 under model 2 but not for model 1.
- The 2014 beginning-of-year spawning stock biomass with model 1 is estimated to be about 98,000 t and in the cautious zone for this stock. The 2014 beginning-of-year spawning stock biomass under model 2 is estimated to be 182,800 t and above the upper stock reference (B_{USR}) level of 172,000 t.
- Risk analysis results of catch options differ between the models. For model 1, there is a 100% probability that the spawning stock biomass will be below B_{USR} (172,000 t) even with no fishing in 2014. A catch option of 22,100 t in 2014 corresponds to a 50% chance that the exploitation rate would be above the reference removal rate. For model 2, a catch option of 38,017 t in 2014 corresponds to a 50% chance that exploitation rate would be above the reference removal rate and a probability of 85% that spawning stock biomass would be below B_{USR}.
- Advice cannot be provided for more than one year (2014) for the fall spawner component because of important and unresolved model uncertainties. A review of the assessment approach is recommended including data inputs and alternate model formulations that could incorporate changes in natural mortality, changes in catchability, and proportionality of indices.

INTRODUCTION

Species Biology

Atlantic herring (*Clupea harengus*) is a pelagic species which forms schools particularly during feeding and spawning periods. Herring in the southern Gulf of St. Lawrence (sGSL) consist of a spring spawner component and a fall spawner component. Spring spawning occurs primarily at depths less than 10 m in April-May, but may extend into June in some areas. Fall spawning occurs mainly from mid-August to October at depths of 5 to 20 m. Eggs are attached to the bottom and large females can produce up to 360,000 eggs. First spawning occurs primarily at age four. In recent years, the largest spring spawning areas are in the Northumberland Strait and Chaleur Bay and the largest fall spawning areas are in coastal waters off Miscou and Escuminac N.B., North Cape and Cape Bear P.E.I., and Pictou N.S.

Fishery

The Total Allowable Catch (TAC) has been set separately for spring and fall fishing seasons since 1985 based on the assessment of the abundance of the spring and fall spawner components. As in previous years, for both seasons, 77% of the TAC was allocated to the gillnet fleet and 23% to the seiner (>65') fleet. Landings are compiled by fishing season (Appendix 1 and Appendix 2).

The 2013 TAC for the spring spawner component was 2,000 t, the same as in 2012 (Figure 2). The combined reported landings of the spring spawner component in both the spring and the fall fisheries were 599 t in 2012 and 1,703 t in 2013.

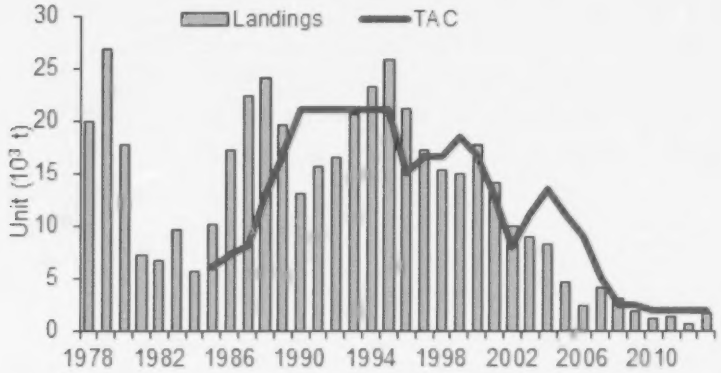

Figure 2. Total landings (t) and total allowable catch (TAC; t) of the Atlantic herring spring spawner component from NAFO Div. 4T, 1978 to 2013.

The catch-at-age of the 2012 spring spawner component was composed mostly of ages 3 to 7. The catch-at-age of the 2013 spring spawner component was composed mostly of ages 4 to 8 (Figure 3). Since 1990, the spring spawner component age 5 average weights-at-age in the fishery have been below those observed during the 1980s (Figure 4). Similar declines in weights at age have been observed for ages 3 to 8. Differences in weights at age between gears (i.e. fleets) are due to differences in timing of the fisheries.

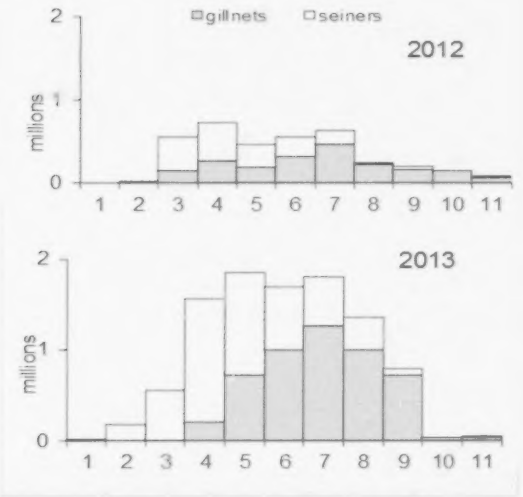

Figure 3. Spring spawner catch-at-age (millions of fish) for 2012 and 2013.

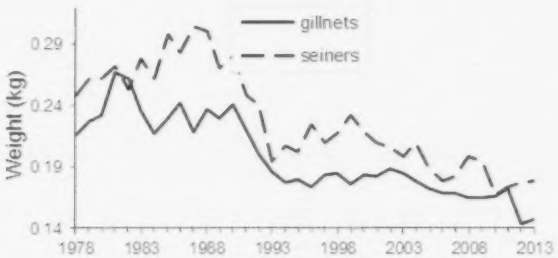

Figure 4. Mean weight (kg) of 5-year-old spring spawners in the gillnet and seiner catches, 1978 to 2013.

The gillnetter telephone survey respondents are asked for their opinion on abundance of herring in the current year relative to the abundance in the previous year. This survey is used to provide an index of harvester opinions on the relative abundance of spring herring. The cumulative index was at a peak in 1998 and declined continually until 2008. There is an improved perspective since 2009 (Figure 5).

Figure 5. Cumulative index of telephone survey spring spawner opinion on abundance, 1987 to 2013.

The TAC for the fall spawner component in 2012 and 2013 was 43,500 t (Figure 6). The combined reported landings of the fall spawner component in both the spring and the fall fisheries were 32,576 t in 2012 and 34,368 t in 2013. The seiners captured 8% of their TAC in 2012 and 50% in 2013, while the inshore gillnet captured 92% of their TAC in 2012 and 88% in 2013 (Appendix 1 and Appendix 2).

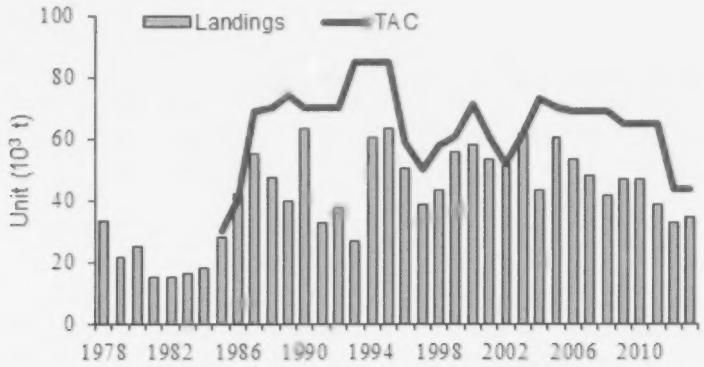

Figure 6. Total landings (t) and total allowable catch (TAC; t) of the Atlantic herring fall spawner component from NAFO Div. 4T, 1978 to 2013.

In the 2012 and 2013 landings of the fall spawner component, ages 6 to 8 were dominant in the catch-at-age (Figure 7). The fall spawner component age-5 average weights in the fishery have been declining since the late 1970s in both the gillnet and seiner catches (Figure 8). Differences in weights-at-age between gillnet and seiner catches are due to the type of fish captured: pre-spawning fish in gillnets, post-spawning fish in seiner catches. Similar declines in weights-at-age have been noted for ages 3 to 8.

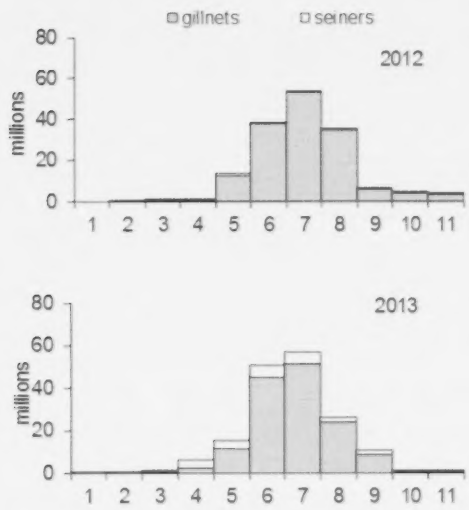

Figure 7. Fall spawner catch-at-age (millions of fish) for 2012 and 2013.

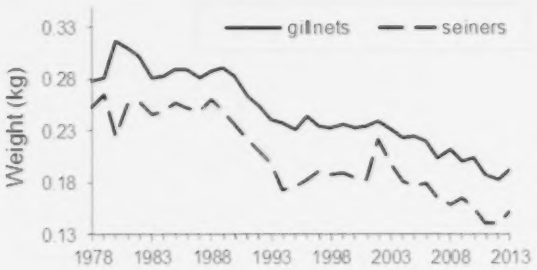

Figure 8. Mean weight (kg) of 5-year-old fall spawners in the gillnet and seiner catches, 1978 to 2013.

The fall cumulative index of opinion of abundance from the gillnet telephone survey has been variable but decreasing since 2006 (Figure 9).

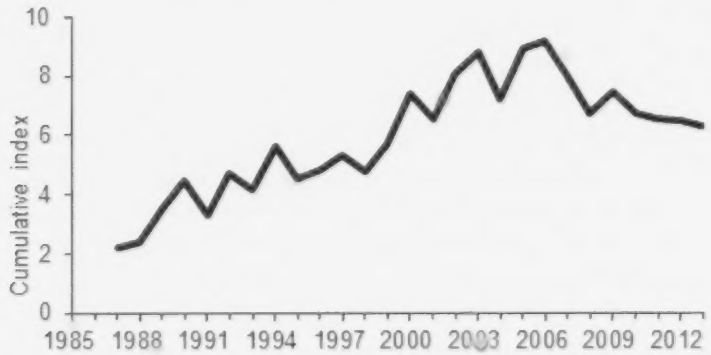

Figure 9. Cumulative index of the telephone survey fall spawner opinion on abundance, 1987 to 2013.

ASSESSMENT

Spring Spawner Component

Stock Trends and Current Status

The determination of resource status of 4T spring spawning herring was derived using a population analysis model calibrated using the age-disaggregated gillnet catch rate (CPUE) and age-disaggregated acoustic survey indices. The overall fit of the population model for the spring spawner component is poor and there are residual patterns for the commercial CPUE index. There is a retrospective pattern in the estimate of spawning stock biomass (SSB). The two

indices used to tune the population model have dissimilar rates of change. This results in greater uncertainty in the estimates of abundance and exploitation rates.

The spring CPUE analysis included dockside monitoring (DMP) and logbook data where available. Effort was calculated using the average number of nets used in each area obtained either from the telephone survey or DMP data. The spring CPUE analysis excluded June data as a large proportion of June catches are of the fall spawner component. CPUE was defined as kg/net/trip. Mean spring spawner gillnet catch rate in 2012 was the second lowest in the time series, the 2013 gillnet catch rate was higher (Figure 10). The index has been declining since 1997 and remains at a low level in the series that starts in 1990.

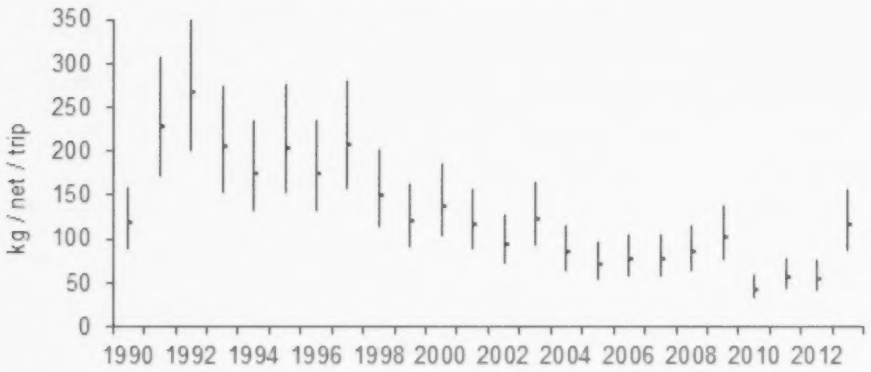

Figure 10. Spring spawner CPUE index (kg/net/trip; mean +/- 2 std. error bars), 1990 to 2013.

The 2012 and 2013 spring spawner acoustic index values were slightly higher than 2011 but remain low in the series that starts in 1994 (Figure 11).

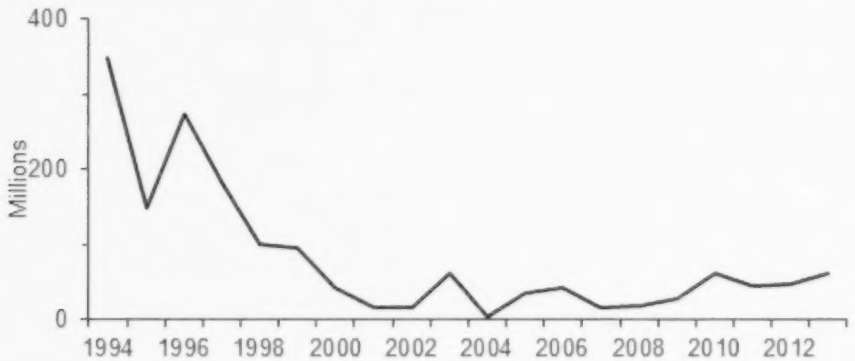

Figure 11. Spring spawner component acoustic survey index (millions of fish) for ages 4 to 8 years, 1994 to 2013.

Both the gillnet CPUE and the acoustic survey indices indicate a decline in abundance since the 1990's, however, the CPUE index indicates a less steep decline than the acoustic survey. Both indices show a slight increase in 2013.

Population biomass (Figure 12) has declined since 1995 and remains at a low level since 2005, but increasing slightly every year since 2006. Age 4+ spawning biomass is estimated at 22,280 t for the beginning of 2014. The abundances of the year-classes (at age 4) after the 1991 year-class were below average (102.6 million). The uncertainties in the model are high. Age 4

abundance in 2014 is estimated by multiplying the spawning stock biomass (SSB) in 2010 by the 2009-2013 average recruitment rate (age-4 abundance in year t / SSB in year t-4).

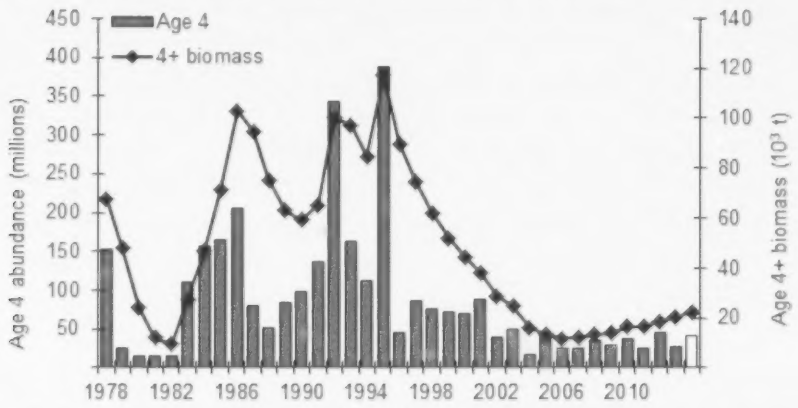

Figure 12. Beginning of year spring spawner component age 4 numbers (millions of fish) and age 4+ spawning stock biomass (10^3 t), 1978 to 2014. The value for age 4 abundance in 2014 is an estimate based on an average recruitment rate of the previous five years.

The reference level exploitation rate at $F_{0.1}$ for the spring spawner component is about 27% for fully recruited ages 6 to 8. The estimated exploitation rate in 2013 was 12% and below the removal reference level (Figure 13).

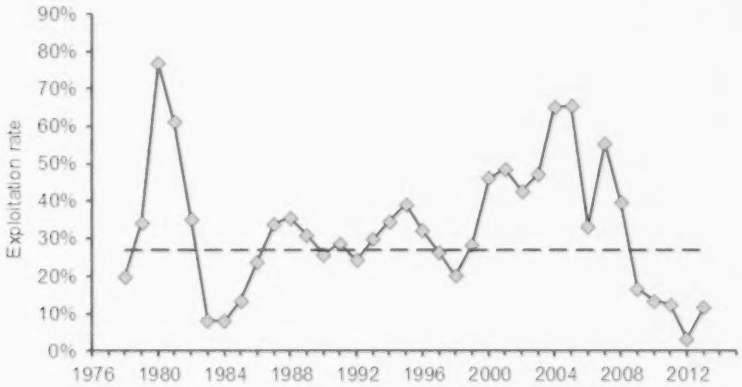

Figure 13. Spring spawner exploitation rates (%, ages 6 to 8), 1978 to 2013. The horizontal dashed line is the reference removal rate of 27% corresponding to $F_{0.1}$.

Sources of Uncertainty

Catches of spring spawning herring used for bait (personal use licence) are not fully accounted for in the landings statistics. Efforts since 2008 to use logbooks and dockside monitoring to record bait licence catches should have improved the reporting. The inclusion of these data in the official statistics and in the assessment has not been completed.

Recent gillnet catch rates remain near the lowest in the time series that starts in 1990 and have uncertainties associated with them. Trips with no catch are not documented prior to 2006 and therefore not incorporated in the effort data. Changes in season openings in 2012 and 2013, which may have affected availability to the fishery, may have resulted in lower CPUE values.

Reduced number of respondents in some areas in the post-season telephone survey is resulting in less information to derive effort information and can change the trends based on the opinion on abundance.

There are no indices of recruitment for ages 2 to 4 for 2014 and 2015, age groups that are exploited by the fisheries and comprise for age 4 an important proportion (30% for the past five years) of the SSB.

Conclusions and Advice

Keeping in mind the uncertainties associated with the model estimates of absolute abundance, the stock is considered to be just above the limit reference point. Estimated exploitation rates in 2012 and 2013 are the lowest of the time series at less than 12%. Estimated abundance has increased in recent years from the low level estimated in 2006 (Figure 14).

For the spring component, the limit reference point (B_{lim}) and the upper stock reference (B_{USR}) point are 22,000 and 54,000 t respectively (DFO 2005). The removal rate reference has been set at $F_{0.1}$, which corresponds to F = 0.35 (about 27% exploitation rate over fully recruited ages 6 to 8). These reference points can be used in the application of a Precautionary Approach (PA) framework for southern Gulf of St. Lawrence herring. The current estimate of age 4+ SSB of 22,280 t is just above B_{lim} (Figure 14).

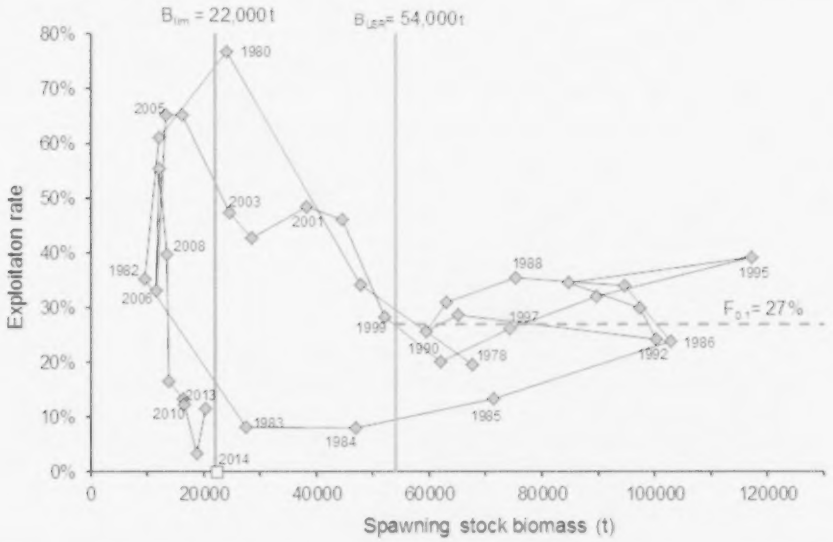

Figure 14. Spring spawner spawning stock biomass (SSB, ages 4+, t) and exploitation rate (%, ages 6-8) trajectory relative to reference points. The spawning stock biomass for 2014 is shown as the labelled white square symbol on the x-axis.

Catch options for 2014 were assessed relative to the following consequences on biomass in 2015: the probability of SSB being below B_{lim}, the probability of a decrease, the probability of a 5% or greater decrease, and the probability of at least a 5% increase (Figure 15). These risk analyses include uncertainties of the population estimates but not those associated with natural mortality, weight-at-age, partial recruitment and uncertainties around the age 4 abundance. The probability that SSB in 2015 will be below B_{lim} is low. A catch option of about 1,000 t in 2014 would provide a 96% probability of at least a 5% increase in biomass, and a 13% chance of being below B_{lim} (Table 1).

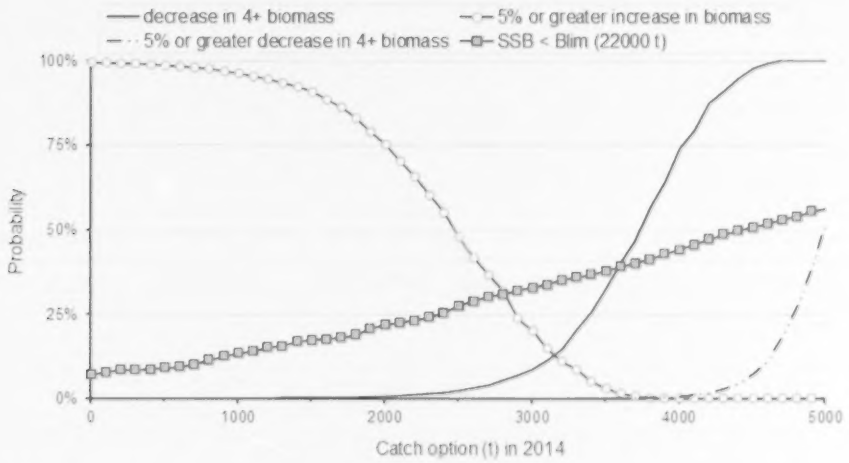

Figure 15. The 4T herring spring spawner component risk analysis of catch options in 2014.

Table 1. Probability (%) of spring spawner biomass in the next year being below B_{lim} and of an increase of at least 5% for different catch options in 2014.

Catch (t)	510 t	1010 t	1510 t	2010 t	2510 t	3010 t
Probability (%) of being below B_{lim}	9	13	17	21	27	33
Probability (%) of at least a 5% increase	99	96	90	75	47	20

There is concern about the low abundance of herring in areas that were important spawning grounds and historically had supported a large spring fishery. The stock has experienced comparable reduction in abundance in the past (1980-84). In those years, good recruitment rebuilt the spawning stock biomass, however, the abundances of year-classes produced after 1991 have been average or below average (Figure 12).

Projections over the next two years were conducted by projecting the population forward from the beginning of 2014 to the beginning of 2016 for different catch options (same levels over the two years), taking into account uncertainty in the population abundance at age at the beginning of 2014. The probability that SSB would be less than B_{lim} at the start of 2016 varied from almost 0% with no catch to 40% with a catch of 5,000 t in each year. The probability of an increase in biomass from 2014 to 2016 ranged from almost 100% with no catch to 18% with catches of 5,000 t each year (Figure 16).

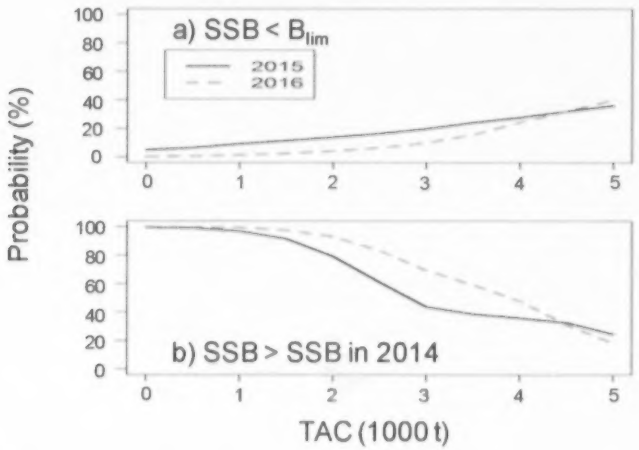

Figure 16. Probability (%) that spawning stock biomass (SSB) of the spring-spawning component a) being below B_{lim} (upper panel) and b) increasing relative to 2014 in 2015 and 2016 (lower panel) at various annual catch levels of 0 to 5,000 t.

Based on the conditions assumed in the projections, there is essentially no chance that SSB will be above B_{USR} in 2016 at any level of catch, including no catch.

Fall Spawner Component

Stock Trends and Current Status

Resource status of the 4T fall spawning herring was determined using a population analysis with two model formulations:

- Model 1 is the same formulation as in the previous assessment to 2012 including:
  - CPUE indices ages 4 to 10 from the fixed gear,
  - acoustic survey juvenile index of ages 2-3, and
  - both indices considered proportional to population abundance in the model.
- Model 2 considers changes in catchability in the gillnets for ages 4 and 5 associated with reductions in size at age observed from 2004 to 2013 with:
  - gillnet fishery CPUE index ages 6 to 10 (1986-2013) as CPUE1 index and ages 4 and 5 (in 1986-2003) as CPUE2 index, both considered proportional to population abundance,
  - ages 4 and 5 (in 2004-2013) as CPUE3 index with a trend in catchability rather than proportional to abundance, and
  - acoustic survey juvenile index of ages 2-3, considered proportional to population abundance in the model.

There are strong residual patterns in both models and both models show retrospective patterns. Two models are presented because the diagnostics of the model fits do not allow a clear choice between models.

The age-disaggregated gillnet catch rate (CPUE) index is based on fishery data of gillnet catches determined from purchase slips and dockside monitoring data (DMP) combined with effort information (number of nets and hauls) derived from DMP data and a telephone survey of 20% to 25% of the active gillnet fishers (Figure 17). The effort information in this index used the product of hauls and nets (haul-net) instead of nets alone. This index covers the entire gillnet

fleet and extends from 1986 to 2013. The mean CPUE in 2012 was lower than 2011 and the mean gillnet catch rate in 2013 was higher than the two previous years. The acoustic index has been declining since 2006 and remains at a low level in the series that starts in 1994 (Figure 17).

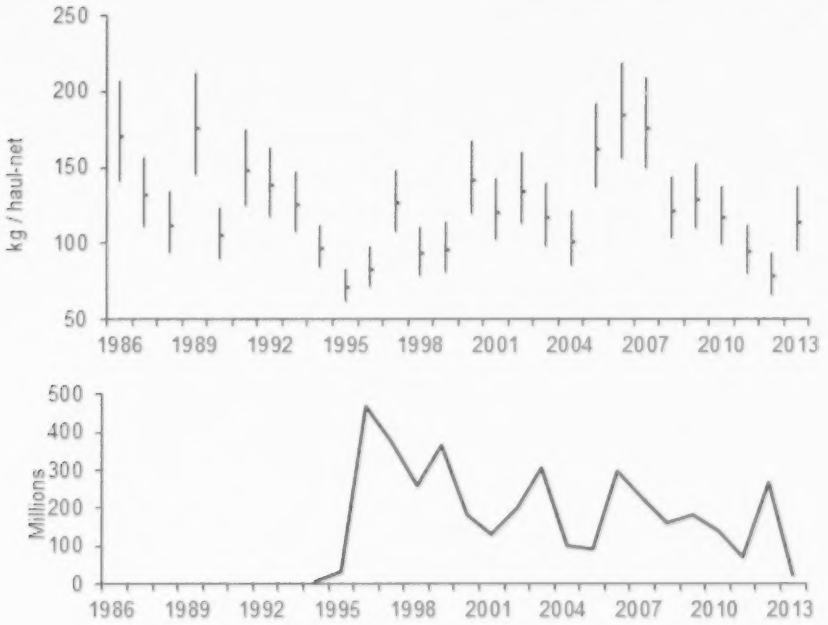

Figure 17. Fall spawner catch rate (CPUE) index (kg/ haul-net) (1986 to 2013) (upper panel) and acoustic index for ages 2 and 3 (1994 to 2013) (lower panel).

The results of stock status in recent years are model dependent (Figure 18).

Recruitment estimates at age 4

Results from Model 1 indicate that the abundances of the 2004 and 2005 year-classes are above the average of 344 million fish, but well below average for the 2003 and 2008 year-classes. Age 2 abundance in 2014 is estimated by multiplying the spawning stock biomass (SSB) in 2012 by the 2009-2013 average recruitment rate (age-2 abundance in year t / SSB in year t-2). Very low abundance is projected for the 2010 year-class.

Results from Model 2 indicate that the abundances of the 2004, 2005 and 2009 year-classes are above the average of 344 million, but well below average for the 2003 and 2008 year-classes. Age 2 abundance in 2014 is estimated by multiplying the spawning stock biomass (SSB) in 2012 by the 2009-2013 average recruitment rate (age-2 abundance in year t / SSB in year t-2). Very low abundance is projected for the 2010 year-class.

Spawning stock biomass

The results from both models indicate that recent spawning stock biomass of age 4+ fall component peaked in 2009 when the large 2004 and 2005 year-classes were contributing to the fishery (Figure 18).

The 2014 beginning-of-year spawning stock biomass (SSB) for model 1 is estimated to be about 98,000 t and below the upper stock reference (B_{USR}) level of 172,000 t. The reference level

exploitation rate ($F_{0.1}$) for the fall spawner component is about 25% for fully recruited age-groups (5-10). The 2013 exploitation rate of 31% is above the reference level (Figure 19).

The estimated SSB for model 2 is about 182,800 t and above the upper stock reference (B_{USR}) level. The 2013 exploitation rate of 21% from model 2 is below the reference level (Figure 19).

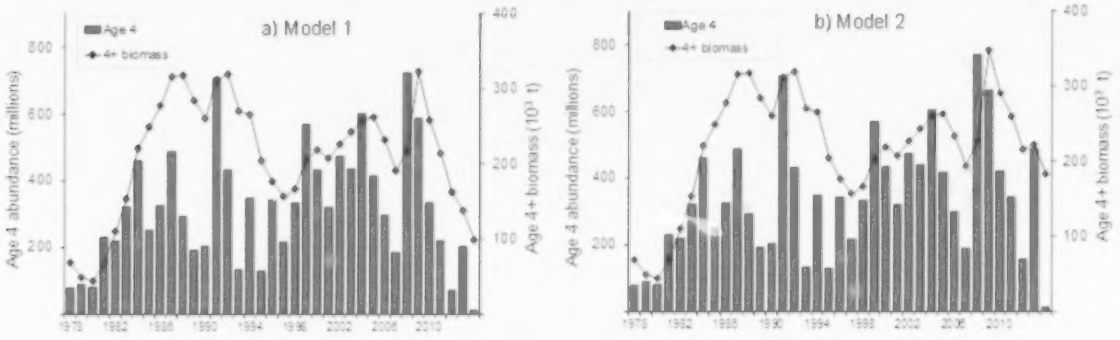

Figure 18. Fall spawner component age 4 numbers (millions of fish) and age 4+ biomass (103 t) from a) model 1 (left panel) and b) model 2 (right panel).

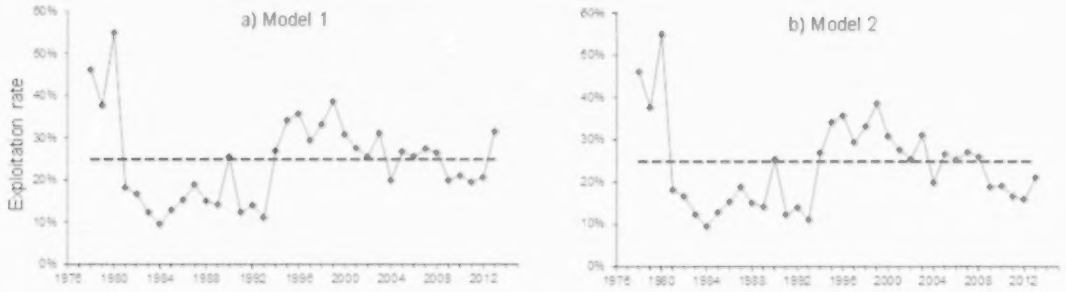

Figure 19. Fall spawner exploitation rate (%; age 5-10) estimates from a) model 1 (left panel) and b) model 2 (right panel). The horizontal dashed line is the reference removal rate of 25% corresponding to $F_{0.1}$ for fully recruited ages 5-10.

Sources of Uncertainty

There is concern that catch rates may not accurately track population biomass because of the nature of the fishery. Boat limits and saturation of nets may impact CPUE negatively, while improved fishing technology could positively influence CPUE. Trips with no catch are not documented prior to 2006 and therefore not incorporated in the effort data. There are potential inconsistencies in the reporting of effort data (number, hauls, length, and depth of gillnets).

The weights-at-age have declined. The fixed gear fishery has been using a relatively constant mesh size over the last ten years and with selectivity being size dependent, this may result in reduced catchability at age particularly for age 4 and 5. This was considered under model 2 in this assessment and the results are dependent upon this assumption. Further work is required to determine if changes in catchability may have occurred for other ages as well, such as age 6.

There are no indices of recruitment for age 2 for 2014 and an average of the previous five-year recruitment rate (recruitment per SSB) is used as has been done in previous assessments.

There are strong residual patterns in both models, including blocks of residuals, suggesting the models do not characterize important dynamics of the population and /or the fishery including possibly hyperstability of the CPUE index (CPUE does not decline as rapidly as population declines), changes in natural mortality, changes in catchability associated with variations in size at age and / or changes in reported fishing practices.

Both models show retrospective patterns. Retrospective patterns may be associated with changes in natural mortality, changes in catchability, and other processes not incorporated in the model.

Two models are presented because the diagnostics of the model fits do not allow a clear choice between models. The estimated absolute biomass values differ substantially between models however the trend in abundance from both is the same; biomass has declined from the recent peak value in 2009 and both models indicate that for catch options at $F_{0.1}$, the biomass is expected to decline in 2015 and could decline into the cautious zone with model 2 whereas the biomass is in the cautious zone and will remain in the cautious zone or decline further with model 1.

Conclusions and Advice

For the fall spawning component, the limit reference point (B_{lim}) and the upper stock reference (B_{USR}) are 51,000 and 172,000 t respectively (DFO 2005). The removal rate reference has been set at $F_{0.1}$, which corresponds to F = 0.32 or about 25% for the fully-recruited age-groups 5-10.

The stock status is model dependent. Under model 1, overall the stock appears to be at a low level relative to the 1984 to 2012 period. Estimated recruitment at age 4 was above average (344 million) from 2002 to 2005, and again in 2008, 2009 and 2010, but below average in 2007 and 2012 (Figure 18). The spawning stock biomass (SSB) is currently estimated to be about 98,000 t and below B_{USR} (Figure 20). Under model 2, overall the stock appears to remain at a moderate level relative to the 1984 to 2013 period. Estimated recruitment at age 4 was above average (344 million) from 2002 to 2005, and again in 2008, 2009 and 2013, but below average in 2007 and 2012 (Figure 18). The current estimate of (SSB) is 182,800 t and above B_{USR} (Figure 20).

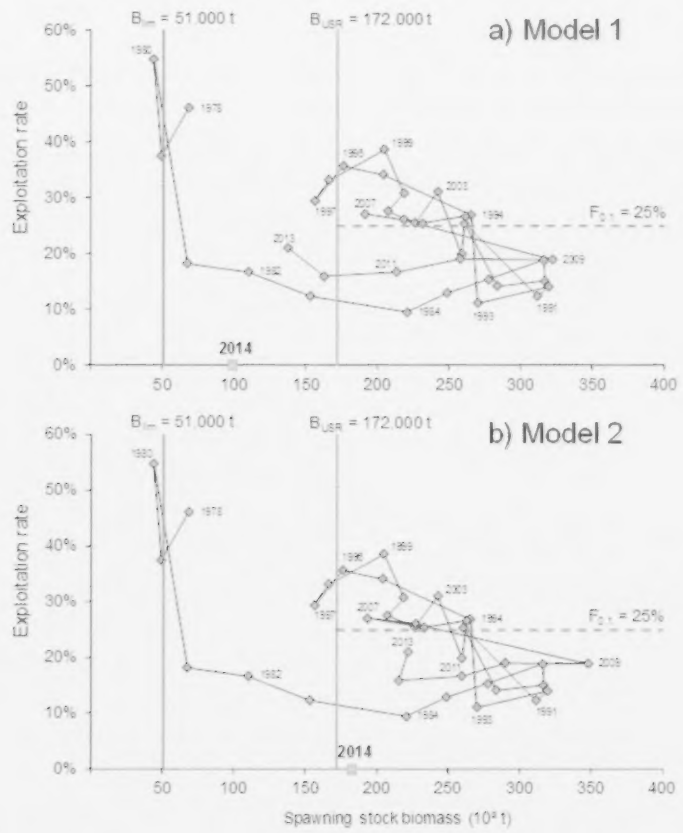

Figure 20. Fall spawner spawning stock biomass (ages 4+, t) and exploitation rate (%, ages 5-10) trajectories relative to reference points for a) model 1 (upper) and b) model 2 (lower). The spawning stock biomass for 2014 is shown as the labelled symbol on the x-axis.

Catch options for 2014 were assessed relative to the probabilities of exceeding $F_{0.1}$, of no decline in SSB in 2015, and that SSB would be less than B_{USR} (172,000 t) in 2015 (Figure 21). Fishing at $F_{0.1}$ is usually considered a safe exploitation rate when the stock is in the healthy zone. These risk analyses include uncertainties of the population estimates but not those associated with natural mortality, weight-at-age, partial recruitment and uncertainties around the age 2 abundance.

For model 1, a catch option of 22,100 t in 2014 corresponds to a 50% chance that the exploitation rate would be above the reference removal rate. There is a 100% probability that the resulting spawning stock biomass in 2015 would be below B_{USR} even with no fishing. For model 2, a catch option of 38,017 t in 2014 corresponds to a 50% chance that exploitation rate would be above the reference removal rate and an 85% probability that SSB in 2015 would be below B_{USR}.

For both models, the risk analysis projects a 100% probability of a decrease in biomass even with no fishing.

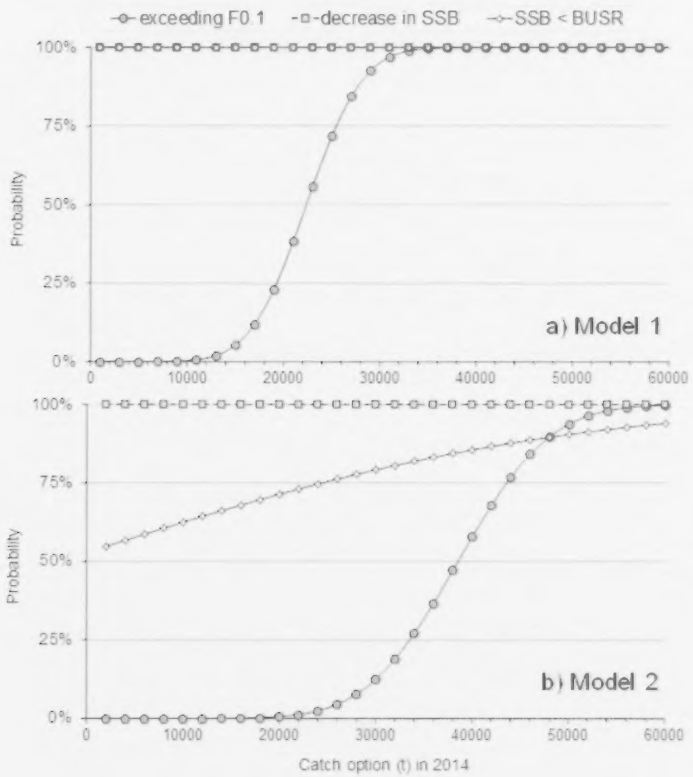

Figure 21. The 4T herring fall spawner component risk analysis for catch options in 2014 based on a) model 1 (upper) and b) model 2 (lower).

Advice cannot be provided for more than one year (2014) for the fall spawner component because of important and unresolved model uncertainties. A review of the assessment approach is recommended including data inputs, alternate model formulations that could incorporate changes in natural mortality, changes in catchability and proportionality of indices.

OTHER CONSIDERATIONS

A number of comments were provided by fishers during the gillnetter telephone survey and by participants at the science review. During the fall fishery, herring were located in deeper water and the fish were smaller. There were concerns about the decrease in abundance (in some areas), the season opening too late, an increase in daytime fishing and increased abundance of herring predators, including tuna.

The mean fork length at maturity (L_{50}) for the southern Gulf of St. Lawrence Atlantic herring stocks for the years 1999-2006 was estimated at 23.5 cm (DFO 2007; LeBlanc and Morin 2008). Based on recent acoustic survey biological data averaged over the 2007 to 2013 period, the mean fork length at 50% maturity (L_{50}) is estimated at 21.6 cm for sGSL herring.

Ecosystem characteristics

No update on ecosystem characteristics was provided. As noted in the previous advisory report (DFO 2012), there have been strong size-structured shifts in the species composition of the

marine fish community of the southern Gulf since 1971. Changes in water temperature, fishing pressure and predation (by fish and grey seals) all appear to have contributed. Whereas fishing mortality on most demersal fishes has decreased to very low levels in the recent years, total mortality on larger fish in several species has increased. Conversely, natural mortality has decreased on small fish and juveniles. Herring are an important component of the southern Gulf fish community, although the spring component represents a lower proportion of the total herring biomass than in the late 1970s. The causes of the reduced abundance of the spring component are presently unknown.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional peer review meeting of March 11-12, 2014 on the Assessment of stock status of Atlantic herring (*Clupea harengus*) from the southern Gulf of St. Lawrence (NAFO Div. 4T). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2005. Spawning Stock Biomass Reference Points for Southern Gulf of St. Lawrence Herring. DFO Can. Sci. Advis. Sec. Advis. Rep. 2005/070.

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LeBlanc, C.H., and Morin, R. 2008. Size at 50% maturity for Atlantic herring in the southern Gulf of St. Lawrence (NAFO 4T). DFO Can. Sci. Advis. Sec. Res. Doc. 2008/021. iv + 19 p.

LeBlanc, C.H., Mallet, A., MacDougall, C., Bourque C. and Swain, D. 2012. Assessment of the NAFO Division 4T southern Gulf of St. Lawrence herring stocks in 2011. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/111. vi + 167 p.

Appendix 1. Total allowable catches (TAC), reserve, and landings overall and by spawning component in the 2012 and 2013 spring (January – June) fishery seasons. Landings are preliminary.

Gear and Area	Spring Fishery TAC (t)	Total Reported Landings (t)[2]	Spring Spawner Component Landings (t)	Fall Spawner Component Landings (t)	% Spring Spawners
2012 Gillnet					
Isle Verte 16A[1]	4	15	15	0	100
Chaleur Bay 16B[1]	71	307	175	132	57
Escuminac 16C	130	6	6	0	100
Magdalen Islands 16D[1]	22	3	3	0	100
Southeast NB – West PEI 16E[1]	454	47	46	1	100
16F[1]	7	19	10	9	53
16G[1]	9	21	11	10	52
Reserve (June 16A-G)[3]	824	[2]	[2]	[2]	na[4]
Reserve (4Vn)[3]	16	0	0	0	na[4]
2012 Total Gillnet	1,537	417	265	152	64
2012 Seiners (>65') 4T	463	228	5	223	2
2012Grand Total	2,000	645	270	375	42
2013 Gillnet					
Isle Verte 16A[1]	4	6	6	0	100
Chaleur Bay 16B[1]	71	377	372	5	99
Escuminac 16C	130	19	19	0	100
Magdalen Islands 16D[1]	22	3	3	0	100
Southeast NB – West PEI 16E[1]	454	450	442	8	98
16F[1]	7	20	15	5	75
16G[1]	9	23	17	6	76
Reserve (June 16A-G)[3]	824	[2]	na[4]	[2]	na[4]
Reserve (4Vn)[3]	16	0	0	0	na[4]
2013 Total Gillnet	1,537	899	874	24	97
2013 Seiners (>65') 4T	463	3,204	180	3,025	6
2013 Grand Total	2,000	4,103	1,154	3,049	28

[1] *Areas that used the reserve after initial TAC was reached.*
[2] *Landings from the reserve are partitioned in areas above.*
[3] *Reserve: The herring reserve allows for setting some quota aside at the beginning of the season, to be redistributed later to areas that catch all of their initial quota and request an extra allocation before the end of the season.*
[4] *na means not applicable.*

Appendix 2. Total allowable catches (TAC), reserve, and landings overall and by spawning component in the 2012 and 2013 fall fishery (July – December). Landings are preliminary.

Gear and Area	Fall Fishery TAC (t)	Total Reported Landings (t)[2]	Fall Spawner Component Landings (t)	Spring Spawner Component Landings (t)	% Fall Spawners
2012 Gillnet					
Isle Verte 16A	88	10	10	0	100
Chaleur Bay 16B	15,093	14,937	14,886	51	>99
Escuminac-West PEI 16CE	6,275	6,833	6824	9	>99
Magdalen Islands 16D	209	0	0	0	na[4]
Pictou 16F	6,145	6,833	6,833	0	100
Fisherman's Bank 16G	5,478	3,273	3,273	0	100
Reserve[1,3]	18	0	0	0	na[4]
4Vn (Area 17)	218	0	0	0	na[4]
2012 Total Gillnet	33,522	31,886	31,826	60	>99
2012 Seiners (>65') 4T	9,978	643	381	262	59
2012 Grand Total	43,500	32,529	32,207	322	99
2013 Gillnet					
Isle Verte 16A	88	20	20	0	100
Chaleur Bay 16B	15,093	15,440	15,440	0	100
Escuminac-West PEI 16CE	6,275	5,935	5,935	0	100
Magdalen Islands 16D	209	36	36	0	100
Pictou 16F	6,145	5,577	5,575	1	>99
Fisherman's Bank 16G	5,478	2,922	2,922	0	100
Reserve[1,3]	18	0	0	0	na[4]
4Vn (Area 17)	218	0	0	0	na[4]
2013 Total Gillnet	33,522	29,929	29,928	1	>99
2013 Seiners (>65') 4T	9,978	2,057	1,409	649	68
2013 Grand Total	43,500	31,986	31,337	650	98

[1] *None of the areas used a reserve in 2012 and 2013.*
[2] *No landings from the reserve are partitioned into respective areas.*
[3] *Reserve: The herring reserve allows for setting some quota aside at the beginning of the season, to be redistributed later to areas that catch all of their initial quota and request an extra allocation before the end of the season.*
[4] *na means not applicable.*

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Centre for Science Advice (CSA)
Gulf Region
Fisheries and Oceans Canada
P.O. Box 5030, Moncton, NB, E1C 9B6

Telephone: 506 851-6253
E-Mail: csas-sccs@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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